Heavy Rare Earths Are a Different Business

written by Jack Lifton | July 27, 2026

"Heavy rare earths are not simply 'the last few elements.' They are a specialty chemical business. And the greatest value comes not from building the largest plant, but from mastering the difficult chemistry." — Jack Lifton, Co-Chair, Critical Minerals Institute (CMI)

China's rare earth industry is not organized as a single monolithic enterprise. The large state-owned groups dominate mining, light rare earth separation, and the production of metals, alloys, and magnets, but the actual separation of the heaviest rare earths—especially dysprosium, terbium, lutetium, yttrium, and the remaining heavy lanthanides—has historically involved much smaller, highly specialized separation plants. These are located particularly in southern China, where the country's domestic ionic adsorption clay deposits are found.

The important question is not simply who does the separation, but why. One of the biggest misconceptions in North America and Europe is that "rare earth separation" is a single technology that merely scales with size. It does not.

Separating a bastnäsite concentrate from Mountain Pass or a monazite concentrate from Australia into lanthanum (La), cerium (Ce), praseodymium (Pr), and neodymium (Nd) is fundamentally a high-throughput chemical engineering problem. Separating dysprosium from terbium—or erbium from holmium—is an entirely different challenge. Their chemistry is almost identical. The differences in distribution coefficients in aqueous and organic media between adjacent heavy rare earths are extraordinarily small. That means a separator cannot simply build a larger solvent extraction plant. Instead, it must dramatically increase the number of extraction stages. A light rare earth plant may today require more than a hundred mixer-settlers. A heavy rare earth circuit may require several hundred.

The economics of separating light rare earths are very different from those of separating heavy rare earths.

For ease, the heavy rare earth elements (HREEs) commonly include:

- Gadolinium (Gd)
- Terbium (Tb)
- Dysprosium (Dy)
- Holmium (Ho)
- Erbium (Er)
- Thulium (Tm)
- Ytterbium (Yb)
- Lutetium (Lu)
- Yttrium (Y)

Some classifications treat gadolinium—and occasionally europium (Eu)—as middle rare earth elements (MREEs) rather than heavy rare earths.

Throughput becomes the problem. Large Western projects generally begin with an engineering assumption: Build one large integrated plant capable of separating everything. This sounds efficient. In reality, it often is not. Heavy rare earth production and demand are tiny compared with production and demand for cerium, lanthanum, neodymium, and praseodymium.

Annual global production of terbium is measured in only a few hundred tonnes. Dysprosium production is only a few thousand tonnes. Trying to force these tiny production volumes through equipment designed for tens of thousands of tonnes annually creates several problems. The equipment becomes underutilized. Inventory trapped inside the extraction circuits becomes enormous. Residence times increase. Working capital requirements explode. Every impurity affects the entire plant. The heavy rare earth circuit becomes a bottleneck for the light rare earth business. China learned this lesson decades ago.

China’s specialization

Instead of one enormous universal separator, Chinese producers evolved a much more modular industrial structure. Large companies produce mixed concentrates or intermediate products. Those materials then move to smaller plants specifically designed for particular feedstocks. Some facilities concentrate on yttrium. Others specialize in dysprosium and terbium. Others produce ultra-high-purity oxides. Each plant becomes extremely efficient at one narrow chemical task. This creates several advantages.

1. Smaller inventories

Heavy rare earths are expensive. A large integrated separator may contain many millions of dollars of rare earth inventory sitting inside hundreds of extraction stages. A smaller dedicated plant minimizes that capital requirement.

2. Better process optimization

Each feedstock behaves differently. Ionic adsorption clays differ markedly from monazite or bastnäsite. Monazite and bastnäsite differ from each other and from xenotime. Instead of designing one compromise flowsheet, each plant can optimize specifically for its feed.

3. Easier technology improvement

A small specialist company can modify its extraction chemistry without disrupting a massive integrated operation. Innovation becomes faster.

4. Market flexibility

If terbium demand suddenly increases, only the relevant specialty plant needs to expand. The entire national separation industry does not need to be redesigned.

Europe and North America may be making a mistake

Many Western ventures appear to be designing their heavy rare earth capability as an extension of light rare earth separation. From an engineering standpoint, this is understandable. The same solvent extraction principles apply. From an industrial standpoint, it may prove inefficient. Heavy rare earths are not simply “the last few elements.” They are a specialty chemical business. The customers are different. The production volumes are tiny. The purity specifications are often tighter. The qualification requirements can be more demanding. This suggests an industrial structure resembling specialty chemicals rather than bulk petrochemicals.

There is another overlooked issue

China accumulated perhaps forty years of operating experience specifically with ionic adsorption clay feedstocks. Operators learned which extraction sequences worked best. They learned where impurities accumulated. They learned how to recycle reagents. Most importantly, they learned how to recover value from tiny streams that Western engineers often regard as process losses. That operating knowledge is difficult to replicate merely by building modern equipment. Industrial capability resides in people as much as in plants. This is a point I have argued repeatedly: Capacity is not the same as capability!

An implication for Western strategy

If I were advising North American or European developers, I would question the assumption that every separator should produce every oxide. Instead, I would advocate a network model. Large separation facilities should recover and partially separate the abundant light rare earths. Smaller, highly specialized plants should handle heavy rare earth fractions, optimized for individual feedstocks and specific customer requirements.

Such a system would reduce capital requirements, improve flexibility, shorten development cycles, and make qualification with end users easier. It would also permit technological improvements to be introduced incrementally rather than requiring the redesign of an entire integrated complex.

This is another example of the principle: follow where value is added. The greatest value in heavy rare earths is not created by building the largest solvent extraction plant. It is created by mastering the difficult chemistry of a handful of elements whose markets are small, whose specifications are exacting, and whose customers care far more about consistent quality than about sheer production volume. The Chinese industry appears to have evolved toward that specialization because experience rewarded it, whereas many Western projects are still attempting to solve a specialty chemical problem with the mindset of a bulk-processing industry.